VOLUME 78 SEPARATE No. 149

PROCEEDINGS

AMERICAN SOCIETY OF CIVIL ENGINEERS

SEPTEMBER, 1952

INDUSTRIAL WASTE TREATMENT IN IOWA

By Paul Bolton

SANITARY ENGINEERING DIVISION

Headquarters of the Society
33 W. 39th St.
New York 18, N.Y.

PRICE $0.50 PER COPY

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Published at Prince and Lemon Streets, Lancaster, Pa., by the American Society of Civil Engineers. Editorial and General Offices at 33 West Thirty-ninth Street, New York 18, N. Y. Reprints from this publication may be made on condition that the full title of paper, name of author, page reference, and date of publication by the Society are given.

Proceedings—Vol. 78 September, 1952 Separate No. 149

AMERICAN SOCIETY OF CIVIL ENGINEERS
Founded November 5, 1852

PAPERS

.INDUSTRIAL WASTE TREATMENT IN IOWA

By Paul Bolton[1]

Synopsis

Ranking first in the United States as an agricultural producer, Iowa also has a large and thriving manufacturing industry. This paper deals with the major sources of industrial pollution of the waters within the state, and the measures taken to reduce this pollution.

Data as to the volume of waste expected, the strength of the waste, and recommended treatment are given for the major industries in Iowa. The paper includes descriptions of the problems encountered in the treatment of wastes from packing houses, locker plants, dairy processing plants, canneries, rendering plants, beet sugar refineries, soybean processing plants, plating shops, and a number of minor industries in the state.

Introduction

Scope.—A paper dealing with industrial waste treatment in Iowa should be prefaced by an explanation of the scope of the subject and the difficulties encountered in obtaining a datum from which to work so that a realistic picture of the over-all problem is given. The subject provides a broad field of discussion, ranging from the establishment that the industrial waste problem exists to the details of specific types or methods of treatment fitted for a particular local situation.

In order to narrow the field of discussion to a comprehensible scope it has been approached from the standpoint of establishing at least three points: First, that a problem does exist, along with an idea of its magnitude; second, that available methods of treatment have cut deep inroads into the promiscuous discharge of untreated wastes to the intra-state streams; and, third, that an extensive problem of stream pollution still exists that must be corrected.

Preparation of an estimate of the situation for a discussion on any of the three points requires a great volume of information that is not readily available.

Note.—Written comments are invited for publication; the last discussion should be submitted by March 1, 1953.

[1] Associate Director, Div. of Public Health Eng., State Dept. of Health, Des Moines, Iowa.

However, through the cooperation of official agencies, industries that have been surveyed by consulting engineers, and the Iowa State Department of Health, and because of the availability of published reports, reliable estimates of the volume of the industrial wastes contributed by the major sources of pollution have been developed.

Sources of Waste.—Although Iowa is considered primarily an agricultural state, the dollar value of manufactured products is as high as, or higher than, the farm income. The estimated value of manufactured products for 1950 was $2,500,000,000 as compared to the 1949 cash farm income of $2,040,530,000. Although it is conceded that Iowa ranks first nationally as an agricultural state, it is probably not realized that it also has 3,856 manufacturing establishments located in 600 cities and towns.

Limitations.—Prior to establishing a datum predicated on the volume of waste to be treated, any evaluation of the industrial waste problem within the state should be commensurate with the provisions of the Iowa Stream and Lake Pollution Law. Until July 4, 1951, the power vested in the Iowa State Department of Health, permitting studies to determine ways and means of eliminating or of controlling the extent of pollution of the waters in or bordering on the state, did not apply to the lower 5,000 ft of any stream flowing into a river at a place where such river forms a part of the boundary line of the state. Therefore any evaluation should exclude the wastes discharged into the Mississippi River, the Missouri River, and the Big Sioux River—and wastes discharged as close as 5,000 ft from such rivers.

Treatment of Packing House Wastes

Magnitude of Waste.—Meat packing is one of the principal sources of pollution in the state. The published receipts of meat processed show that Iowa led the nation in 1949 with 4,148,000,000 lb of live weight. Although this is only $11\frac{1}{2}\%$ of the "kill" in the nation, it represents a sizeable industrial waste problem both as to volume and constituents.

Utilizing the 1949 published receipts of livestock at public yards, an estimate of the disposition to packers can be established without reference to any individual plant. The processing of all types of animals within the state represents a flow of waste of approximately 20,400,000 gal per day. Deducting the quantity discharged into those waters in or within 5,000 ft of the border streams, this amounts to a flow of 17,800,000 gal per day which is under the jurisdiction of the stream and lake pollution law. In terms of untreated wastes, and based on biochemical oxygen demand (B.O.D.), the volume processed would represent 155,000 lb for the entire kill, or 136,000 lb per day discharged into intra-state waters. These values are based on working days and do not represent the maximum volumes during periods of maximum kill. Of the quantity discharged into the intra-state streams, approximately 70% is treated in privately-owned plants or in combination with domestic sewage in municipally-owned treatment plants. Only one major packer located on an intra-state stream remains without some degree of treatment.

A review of the information available on the expected contributions of waste from the packing industry presents an interesting study. F. W. Mohlman[2] in a study of fourteen Chicago (Ill.) packing plants, and two plants outside Chicago, determined the quantities listed in Table 1. A few results from the files of the Iowa State Department of Health are also given. On the subject of packing house wastes, R. W. Bates[3] states that good packing house control makes it possible to maintain a value of $2\frac{1}{2}$ lb of B.O.D., per equivalent hog, in the raw screened effluent of a killing plant. This value corresponds to 20 lb per ton of live weight.

Handling of Packing House Waste.—The reporting of B.O.D. and volumes of packing house wastes should not be misconstrued to mean that these analyses are all that are needed to design a treatment plant adequately. The suspended solids content (which may range from well below 50% of the B.O.D. to values exceeding it) is extremely important in calculating the volume of solids to be handled. The grease content should also be a guide to the necessity of grease removal units. The presence of each of these items can be affected materially by the operations within the plant itself. Efficient recovery of grease and nitrogenous materials as a by-product, and for treatment purposes, may eliminate the necessity of grease removal equipment in the treatment process and reduce clarifier sizes if little of the material is settleable.

TABLE 1.—RECORD OF PACKING HOUSE WASTES

Description	Reported by F. W. Mohlman[a]					Iowa State Dept. of Health		
	Hogs	Cattle	Mixed kill	Mixed kill	Mixed kill	Mixed kill	Beef[b]	Hogs[b]
Number of plants averaged	four	four	six	one	one	...	...	...
Average water used[c]	4,275	3,225	4,633	4,080	4,900	3,690	1,700	424
Biochemical oxygen demand[d]	28.0	28.5	29.9	17.8	43.1	15.75	7.89	8.00

[a] The first three columns refer to packing plants in Chicago, Ill., and the fourth and fifth columns to packing plants outside the city. [b] Water loss and B.O.D. for these plants are given in units per animal. [c] Except as noted in the last two columns, these values refer to the average gallons of water used, per ton of live weight processed. [d] Except as noted in the last two columns, these values refer to pounds of the biochemical oxygen demand, per ton of live weight processed.

It is usually much cheaper, when practicable, to handle waste materials in the dry, semi-dry, or separate form rather than diluted with water for removal from the immediate premises. The latter course involves installing expensive treatment facilities to remove the waste from the water carried system. The handling of paunch contents in the semi-dry state, the conscientious collection of all blood, and the prevention of carry-overs from cookers, are examples of practices that help reduce the volume of pollutional material.

A good research and recovery program is a vital part of any plant or industry program to reduce the quantity of waste, to facilitate treatment,

[2] "Packing House Industry," by F. W. Mohlman, *Industrial and Engineering Chemistry*, May, 1947, pp. 637–641.

[3] "A Discussion of Packing Plant Waste Disposal," by R. W. Bates, Annual Meeting of the Iowa Sewage Works Assn., 1948 (unpublished).

and, in many instances, to increase income from the sale of recoverable products, or to reduce the losses in the processing of the raw material.

Examples of Packing House Waste Treatment.—One of the first plants installed for the treatment of packing house wastes exclusively was constructed because of an acute stream pollution condition in one of the smaller streams of the state. An activated-sludge plant was installed in the early 1920's to treat the wastes. Although the plant was increased in size soon after installation, it was later abandoned in favor of biological filters because of the difficulties encountered in the operation and control of the activated sludge, and the sludge disposal problem.

The two-stage biological filtration plant was constructed in 1928. The units utilized are as follows: Flocculator, pre-settling tank, primary clarifier, primary filter, intermediate clarifier, equalizing tank, final filter, and final clarifier.

One of the unusual units in the plant is the primary filter. This is a rectangular trickling filter 3 ft deep. The filter is equipped for backwashing to eliminate the clogging that would be expected in a unit that operates at a load reaching 16,500 lb of B.O.D. per acre-ft, and with a water loading of only 5,000,000 gal per acre per day to 8,500,000 gal per acre per day. The filter has proved its value in the treatment at this plant since it removes approximately 55% of the applied load.

The second-stage filter, $7\frac{1}{2}$ ft deep, is also quite heavily loaded from a B.O.D. standpoint: One calculation indicates 1,100 lb per acre-ft loading, although much higher loadings have been reported. This plant produces an effluent of less than 50 ppm of B.O.D. most of the time.

Another type treatment is practiced at Waterloo, Iowa, where the effluent of the packing house grease removal units and fine screens is treated through the municipally-owned plant. The packing house wastes are pumped directly to pretreatment units without mixing with the domestic wastes. The pretreatment installation consists of grit removal and grease removal units, a primary clarifier, and roughing filters. The effluent of the roughing filters can be mixed with the raw domestic wastes or with the domestic wastes following treatment in the detritors and grease removal and flocculation units. The combined wastes are then treated through primary clarifiers, conventional biological filters, and final clarifiers.

The roughing filters for the packing house waste are 6 ft deep and operate at B.O.D. loads of from 5,000 to 9,300 lb per acre-ft. No recirculation is employed on these units and the water loading is considerably less than the high-rate range. A limited number of results indicates a removal of from 48% to 56% through the roughing filters, and an over-all pretreatment plant removal of from 77% to 82%. The B.O.D. of the raw packing house waste, as received at the treatment plant, ranges from 1,000 ppm to 2,000 ppm.

The second-stage filters that receive the combined pretreated load and the city clarified waste are $7\frac{1}{2}$ ft deep. These filters operated at loads ranging from 600–800 lb of B.O.D. per acre-ft to 1,800–2,400 lb per acre-ft, depending on the contribution of the industrial establishments. The results on these filters, in combination with the final clarifiers, indicate removals of from 75% to

88%. It should be noted that the remarkable removals through the filters are accompanied by a corresponding degree of supervision to prevent ponding and clogging.

A review of the 1950 reports indicates a final effluent with B.O.D. ranging from 18 ppm to 72 ppm in February to 18 ppm to 34 ppm in July. These results follow the pattern of loading on the treatment facilities. The plant is heavily overloaded and expansion is needed.

In Iowa most of the plants treating packing house wastes combined with municipal wastes employ two-stage biological filters, especially where the packing house waste is the "tail that wags the dog." Exceptions to the two-stage filter process are Cedar Rapids, Des Moines, and Marshalltown. Cedar Rapids and Des Moines use single-stage filters and Marshalltown employs the activated sludge process.

Activated sludge at Marshalltown has been successful as far as treatment is concerned but has required considerable operation. The dilution of the packing house wastes with sizeable quantities of other wastes may be one of the contributing factors to the success of the process. Mr. Mohlman attributes the success attained in treating the Chicago packing house load at the southwest treatment works, by the activated-sludge process, to the fact that considerable dilution with other wastes is available.

Filter Design.—In passing from a discussion of packing house waste to other wastes it should be emphasized that the filter loads quoted are higher than would normally be used in design, particularly on second-stage filters. Relatively deep filters at lower loadings are less susceptible to an immediate deterioration of effluent resulting from sudden increases in applied strengths, and can generally be relied on for a more stable effluent because of better nitrification. Of course, there are other factors to be considered in filter design.

Treatment of Locker Plant Waste

Another waste resulting from the killing of animals (and similar in some characteristics to packing house wastes) is the effluent from locker plants. According to the Iowa State Department of Agriculture, 686 locker plants are registered and licensed. Of this number, approximately 3.6% are situated where the waste would discharge into border streams. A sufficient number of plants have been surveyed to give a representative cross section of the wastes involved.

Characteristics of the Waste.—The estimates of the B.O.D. of this industry are based on good housekeeping within the "killing" plants. This includes the exclusion of parts of animals, meat, hair, and the contents of the intestines from the sewers, the collection of all blood, and squeegeeing of floors and tables prior to the washdown of equipment. The offal of the killing process, in most instances, is collected and processed by by-products companies.

The wastes discharged into the streams in the interior of the state from this source are estimated at 1,048,000 gal and 12,300 lb of B.O.D. per day. Approximately 43% is discharged to treatment plants and the remainder is untreated. Of the waste reported as treated, approximately 10% is discharged

into septic tanks without further treatment and therefore the effectiveness of the treatment provided is questionable.

Treatment Problems.—The small size of the locker plants, as a general rule, complicates the treatment of the wastes. Two or three of the small establishments have installed septic tanks, followed by subsurface absorption fields, in an effort to remedy the immediate problem. The septic tanks and soil absorption systems were both leniently designed. The first such unit was installed on a trial basis and about a year later was reported as still functioning satisfactorily; a very limited number have been built with no further word from the owners. This type of treatment and disposal system is not recommended but is mentioned because of the results attained. The problem of the small locker plant that must treat its own waste should be studied by the industry itself.

The discharge of these wastes in appreciable quantities into municipal sewerage systems with sand filters usually causes considerable difficulty. If good housekeeping is practiced in the plant, very little of the waste will settle; therefore the treatment is largely dependent on the secondary facilities. In the removal of this organic matter, sand filters clog frequently and require drying and skimming.

Treatment of Dairy Industry Wastes

Magnitude of Problem.—The waste contributed by the dairy industry is of considerable magnitude, as can be deduced from the volume of dairy products produced in 1949. The Iowa Crop and Reporting Service has revealed that the whole milk equivalent of manufactured dairy products totaled 4,414,000,000 lb. The products manufactured by the dairy industry vary widely and produce wastes with a wide range of strength and constituents. The wastes from butter manufacturing will vary in B.O.D. content from 500 ppm–600 ppm to as high as from 1,500 ppm–5,000 ppm. These findings are quoted on the basis of a good program of waste prevention in the creamery and the collection of all buttermilk and spillage without discharge to the sewer system. The ease with which these values are increased as a result of spills or poor operating conditions is readily evident when the B.O.D. of the products handled is known. Whole milk has a 5-day B.O.D. of approximately 102,000 ppm; skim milk, 73,000 ppm; buttermilk, 64,000 ppm; and the whey from cheese plants 32,000 ppm. In other words, small quantities of these wastes have a sudden impact on treatment facilities.

A report of the Waste Disposal Task Committee of the Dairy Industry Committee stresses very strongly the role of waste prevention in waste treatment. The committee reports that good operation methods can keep the waste loss in receiving operations at less than 0.35%.

The manufactured products are the bases of estimates of the status of industrial wastes since, of the 5,921,000,000 lb of milk produced on the farm, only 2% is used for retail sales to consumers. According to the 1949 report of the Iowa Department of Agriculture, there are 390 creameries, 831 skim milk stations, 23 central churning plants, and 30 cheese factories within the state.

It is estimated that the manufacturing processes of the dairy industry produce 3,393,000 gal of waste and 37,549 lb of B.O.D. per day. These values are based on the estimated number of working days and do not include seasons of maximum production. The quantity produced in the interior of the state, in accordance with the coverage of the stream and lake pollution law, reduces this waste to 3,040,000 gal and 33,300 lb of B.O.D. A cross section of this industry, based on creamery wastes disposition, indicates that approximately 49% of the waste goes into private sewer lines without treatment, 14% discharges into private sewer lines with treatment, 13% into municipal sewers without treatment, and 24% into municipal sewers with treatment.

The volume discharged into private sewer lines with treatment should be viewed with caution. In most instances, this consists of septic tank treatment only, which has not proved effective for the adequate reduction of dairy wastes even as primary treatment.

Treatment Procedures.—Milk wastes consist largely of organic solids, fat, milk sugars, and protein in the form of casein. The breakdown of the milk sugars into acids, primarily lactic acid, and the development of lethal levels injurious to biological life in the treatment processes, indicate that milk wastes should be treated while fresh, and treatment should be under aerobic conditions. Max Levine, in research work at the Iowa Engineering Experiment Station (Iowa State College, at Ames) showed that the production of ammonia in the treatment of protein wastes practically ceased when appreciable quantities of milk wastes were added.[4] At the same time, the acidity materially increased, retarding the action of the ammonia forming organisms.

W. E. Galligan and Mr. Levine proved[5] that dairy wastes were amenable to biological filtration in their studies of milk waste treatment in the late 1920's and early 1930's. Filters loaded in the standard rate range of from 375 to 600 lb per acre-ft per day (or from 1,120 lb to 1,640 lb for the 8 hr of operation) reduced the raw waste (from 480 ppm–1,240 ppm of B.O.D. to 30 ppm–60 ppm of B.O.D.) in the final effluent. Approximately 95% removal was effected when using a quartzite rock from 1 in. to 2½ in. in size. Such plants were installed at two creameries and the results quoted are from one of the plants under operating conditions.

With the introduction of the high-rate filter, many of the dairy industries desire to use them for the treatment of wastes because of the economy of installation compared to standard rate filters; but there is not a sufficient accumulation of results on high-rate filters to determine a reliable expected removal through these units.

H. A. Triebler and H. G. Harding of the National Dairy Research Laboratories also reported[6] a lack of results in their discussion of dairy industry wastes. From a review of all types of treatment available they reported that one-stage or two-stage trickling filters of the high-rate recirculating type appear to be

[4] "Fundamentals in the Purification of Creamery Wastes," by Max Levine, *Bulletin 77*, Eng. Extension Dept., Iowa State College, Ames, Iowa, Vol. XXIV, No. 20, October 14, 1925.

[5] "Purification of Creamery Waste on Filters at Two Iowa Creameries," by W. E. Galligan and Max Levine, *Bulletin 115*, Iowa Eng. Experiment Station, Iowa State College, Ames, Iowa, Vol. XXXII, No. 44, April 4, 1934.

[6] "Dairy Industry," by H. A. Triebler and H. G. Harding, *Industrial and Engineering Chemistry*, May, 1947, pp. 608–613.

preferred in the dairy waste field, depending on the degree of treatment required. This preference was attributed to relatively low initial and operation costs and to the fact that these units are fairly foolproof and immune to disturbances resulting from occasional overloading.

One filter installation in Iowa reduced the B.O.D. of dairy waste from 2,290 ppm to 970 ppm or 58%. The filter load was 1,920 lb of B.O.D. per acre-ft for the 10-hr daytime period of treatment plant operation, based on the settled applied waste, or 4,560 lb of B.O.D. per acre-ft for the total applied, whereas the hydraulic load was only one third of that considered to be in the high-rate range. These results were from a single composite. Changes were made in the operation of the plant and the water loading on the filter was increased to 20,000,000 gal per acre per day. A plant study gives the following data: The raw waste had a B.O.D. of 7,500 ppm and the final effluent, 400 ppm for a 94.7% removal. Although processing in the dairy plant ceases at about 2:00 p.m., the treatment plant runs continuously. The waste is cycled through the filter until 5:30 a.m. and then a sufficient amount is diverted to the final settling compartment and the receiving ditch so that, by the time the processing starts, the holding basin receiving the raw waste is drawn down sufficiently to hold the day's flow. The filter effluent returns to the raw sewage holding basin and is continuously aerated by compressed air.

Processes are available, therefore, for treating milk wastes separately but, because of the high cost of constructing standard rate filters and an insufficient amount of operating data to forecast the efficiency of high-rate filters adequately, the need for further study is evident.

Combined Treatment.—The treating of large quantities of milk wastes combined with domestic wastes has presented problems. The formation of acids through the breakdown of milk sugars has eliminated the use of Imhoff tanks as primary treatment units because of the interference with digestion, and accompanying foaming. In some instances in which Imhoff tanks are used, the creamery waste, after adequate grease and grit removal, has been carried to the treatment plant site and discharged directly into the filter. This by-passing of the primary units has eliminated interference with their operation.

Treatment of Cannery Wastes

The canning industry (including only the plants limited to vegetable canning) produces a large quantity of waste, in season, which is high in B.O.D. and the industry is noted for its use of copious quantities of water. The waste putrefies quite rapidly if not treated and emits obnoxious odors, giving rise to nuisance conditions.

Waste.—A resumé of the size of the vegetable canning industry located in the interior of the state gives a close approximation of the volume and disposition of its wastes. The total waste from the industry is approximately 4,178,000 gal per average day of operation, of which 2,848,000 gal is produced in the interior of the state. The estimate is based on polluted wastes only, and does not include cooling water used in those plants in which separation is practiced. The total B.O.D. contained in the 2,848,000 gal of waste is estimated to be 80,200 lb. The waste varies in strength in accordance with

each individual plant, the product canned, and the volume of water in which the waste is carried. Selecting random results from the files, the B.O.D. strength of composite samples of the waste varies from 1,400 ppm to 4,000 ppm. Stack wastes, resulting from corn canning, will be as high as 32,000 ppm in B.O.D. and, if mixed with the processing wastes, raises the organic content substantially.

The wastes produced in the interior of the state can be further broken down into 167,000 gal per day lagooned, 1,780,000 gal irrigated, 653,000 gal discharged into municipal treatment plants, and 279,000 gal untreated.

In most instances, canning plants are located in small communities near the source of the raw products. The tremendous seasonal load disrupts local sewage treatment facilities, not designed for the additional waste, to the extent that little effective treatment is accomplished. This condition, plus severe conditions of stream pollution, necessitated either the provision of additional treatment units or the development of other methods of disposal.

Methods of Treatment.—Lagooning was tried at a number of places and some lagoons are still in use. Difficulties with some lagoons developed because of odor nuisances. The breakdown of the organic matter in the lagoons emits objectionable odors, requiring careful isolation of the ponds, or chemical treatment. Odors can be inhibited through the use of sodium nitrate in sufficient quantities to satisfy approximately 20% of the B.O.D. Lagoons must also be located carefully to secure the proper type of subsoil, to prevent seepage into coarse gravel and subsequent discharge into streams without sufficient filtration.

Because of the difficulties or objections anticipated with other methods of treatment or disposal, irrigation in shallow trenches was tried in 1934 and 1936. The only pretreatment was screening of the wastes with fine mesh screens. This waste was pumped into irrigation trenches approximately 24 in. wide at the top, 15 in. wide at the bottom, and from 9 in. to 18 in. deep. The ridges between the furrows were from 3 ft to 3½ ft wide. It was learned that, if the trench bottoms were maintained level for the full length, and if no trench was reused until after dewatering and drying, a relatively small acreage would dispose of the wastes from a sizeable canning plant. The objectionable odors of lagooning were also avoided by this method.

An irrigation field must be located where the soils are of such a substance and texture that they will readily absorb the wastes, and the field must be properly supervised to function satisfactorily. Two of the fields studied have disposed of approximately 100,000 gal to 150,000 gal of waste per acre per day.

Treatment of Rendernig Wastes

The rendering industry has presented a particular problem in the disposal and treatment of wastes because of the isolated locations of the manufacturing plants. This requires private treatment facilities and, in most locations, a good degree of treatment because of the nature of the waste.

Magnitude of the Problem.—The use of barometric condensers for cooker control materially increases the quantity of wastes involved and the size of treatment plant required. The entrained organic matter in the barometric

condenser water or the quantity carried over from the cookers through normal or careless operation is generally sufficient to necessitate treatment. In an attempt to reduce the volume of waste requiring treatment, the industry has been encouraged for years to utilize vacuum pumps for the control of cookers. At first this suggestion was resisted because of the fear of insufficient quality control on the products. Only in recent years has the use of vacuum pumps in this area been utilized for such purposes. The cooling water for condensing the discharge of vacuum pumps can be divorced entirely from pollutional material and, at the same time, is available for dilution of the treatment plant effluent.

The seventy-two plants registered in the State of Iowa are widely scattered and in only two or three locations is all the waste discharged into municipal systems with treatment plants. One or two other plants are so located, but only part of the waste discharges into the municipal sewers. Some of the plants are equipped with septic tanks but, for the purposes of estimating the volume of treated wastes, these plants are not included since, in most locations, they do not provide adequate treatment. The total waste discharged from the industry is estimated to be 4,680,000 gal and 18,000 lb of B.O.D. per day. Approximately 3.5% is discharged into municipal systems and treated and another 10% is credited with treatment in privately-owned plants.

Methods of Treatment.—A treatment plant, consisting of a high-rate backwash type, aerated filter was installed to treat the wastes from one of the rendering plants. The filter was arranged for recirculation, the filter effluent being returned to the recirculation pump sump. The solids were to be collected on the filter, backwashed into the settling tank, and, after settling, lagooned for disposal. The filter medium was $\frac{5}{16}$-in. by $\frac{9}{16}$-in. anthracite. Forced draft filter ventilation was included in the design. The outlet from the plant was through the wet well for the pump discharging into the anthracite filter.

After a 3-week or 4-week period of operation, observations were made on the effluent. The plant effluent had a soapy, whitish-gray appearance. Analyses on the waste by a commercial firm indicated a reduction of 61% in B.O.D. and 51% in suspended solids. The raw waste contained 166 ppm suspended solids and 370 ppm of B.O.D. and the final effluent contained 81 ppm suspended solids and 144 ppm of B.O.D.

Later observations indicated an effluent of the same appearance as previously noted, and grab samples collected after backwashing the filter showed no reduction in B.O.D. between the settling tank effluent and the final effluent. These samples were collected at an inopportune time but represented the strength of waste discharged by the plant after backwashing. The grid for aerating the filter was not in use at the time the grab samples were collected.

A different type of disposal system was constructed at another rendering plant. This treatment plant consisted of a grease trap for the collection of floating material and settleable solids, followed by a subsurface filter absorption system. The settling tank was too small for effective settling. The filter absorption system consisted of a large pit filled to a 4-ft depth with 1 in. to 4 in. washed rock. Distribution was accomplished by laying farm-tile lines on $4\frac{1}{2}$-ft centers longitudinally over the rock. The joints in the tile were

covered with burlap and a layer of from 18 in. to 24 in. of clay. This installation operated for approximately two years before the filter absorption system clogged. The management, however, feels that it has been sufficiently successful, and they are planning to install a second such system with larger units.

In 1947 a plant of the separate sludge, high-rate filter type was installed to treat the wastes from one plant prior to discharge into a practically dry run. The wastes had been causing gross pollution in the receiving ditch and were creating an odor problem. The plant was installed and designed to treat the wastes from the unloading room, cooker room, hasher, and washer, and also the sanitary wastes of the employees. A study of the barometric condenser wastes had indicated that the B.O.D. was sufficiently low to be controlled by chlorination. Soon after operations were started it was found that the barometric condenser waste was not being controlled by the available chlorinator, particularly when the material for processing was received in a bad state of decomposition.

After a number of meetings of the plant officials, the consulting engineer, and the Iowa State Department of Health, it was decided to install vacuum pumps and surface condensers to reduce the volume of polluted waste so that it could all be discharged into the treatment plant. A blower was installed to take suction from the top of the old chlorine contact tanks and maintain a vacuum on the cookers. The cooling water was sprayed on the outside of the contact tanks to condense all the waste possible from the cookers. The condensed wastes are discharged into the treatment plant. The blower discharges the noncondensable gases into the fire box of the gas-fired plant boiler. The cooling water is collected without contact with polluting material and directed to the treatment plant outfall line for dilution of the treatment plant effluent.

This change-over immediately reduced the loadings on the plant. In addition to the 10,000,000-gal-per-acre-per-day filter, 8 ft deep, with a straight-line clarifier ahead of it, a nonmechanical, conical, final clarifier was installed following it, and an open-sludge digester with sludge beds for the disposal of the removed solids. Recirculation is accomplished through the primary clarifier.

Three studies of this plant have been made. Composite samples of the effluent indicated the B.O.D. to be 40 ppm and 43 ppm during periods when the average load of fresh material was being processed and 160 ppm during a period of heavy production of partly decomposed material. The recirculation ratio varies from 5 to approximately 14. The calculated filter loading, based on total applied, was 0.134 lb per sq ft per day, when the effluent had a B.O.D. of 43 ppm.

The treatment of reducing plant waste is in the research and development stage and more experience on plant-scale applications is necessary to determine the suitability of the available processes in regard to permissible plant loadings to produce a required effluent.

Treatment of Other Industrial Wastes

Beet Sugar Processing.—A large sugar processing firm located on a relatively small stream has controlled its wastes for a number of years by ponding.

The wastes consist principally of beet wheel water, battery and pulp press water, lime flume water, and Steffen's waste water. All the wastes, amounting to approximately 3,000,000 gal per day, are discharged into the ponds. Some of the wastes are later reclaimed but approximately 2,500,000 gal per day are stored for release into the river during periods of high runoff in the spring. The strength of these wastes can be judged by the beet flume water which contains from 350 ppm to 500 ppm of B.O.D., or higher if spoiled beets are used. The pulp water contains a B.O.D. of from 700 ppm to 900 ppm and the Steffen's waste has a B.O.D. of 3,000 ppm. The Steffen's waste, amounting to a sizeable volume, is one of the wastes now reclaimed. The lime flume water is lagooned separately for lime reclaiming. In the spring, the release of the water to the receiving stream is controlled by the analyses of the ponded waste and the volume of flow in the stream. Curves were developed based on the flow in the stream, the temperature of the stream water, the strength of the waste released from the ponds, and the apportionment of the allowable oxygen available for use in the stream water among the various users in the area. This control arrangement has prevented heavy pollutional conditions in the receiving stream since the implementation of the procedures.

Poultry Industry.—The size of the poultry industry can be estimated from the 1947 production figures. The total production was 48,198,000 head, of which 2,565,000 were turkeys. Ninety-one plants are listed as processing poultry, some of which have a capacity of several thousand birds per day. Poultry packing wastes are amenable to treatment by biological filtration. Poultry dressing establishments are usually located with access to municipal sewers and the wastes are treated in combination with municipal sewage. The strength of these wastes varies from 300 ppm to 1,000 ppm of B.O.D., depending on the efficiency of blood collection and the method of handling battery manure.

Soybean Processing.—Soybean processing in Iowa is a sizeable industry. The plants may be of the expeller type but, in general, extraction is used for the removal of the oil from the beans. The use of hexane in the extraction process adds the danger of explosion or fire, if accidents occur, and appreciable quantities of the solvent escape to the sewer or treatment processes. If the wastes discharge into sewers and are well diluted no difficulty has been reported in the treatment. It is imperative that escape-proof units be provided between the plant and the sewer system to prevent, positively, the admission of hexane to the sewerage system. Trichlorethylene is a noninflammable solvent but is not widely used. It does eliminate the explosive or fire hazard, however.

At isolated plants without treatment facilities, most of the treatment has been within the plant in the form of recovery. Better hexane recovery methods have been employed, as well as recovery of the soybean meal. Only a limited amount of information is available on strengths; however, the data available indicate that the B.O.D. can be reduced from approximately 300 ppm to 100 ppm by improved recovery processes.

Although it is known that the hexane carry-over can be quite readily volatilized out of the waste, no other data relative to treatment are available. It is a problem that will require study to develop suitable processes of treatment.

Plating Industry.—In Iowa, the plating industry has grown in connection with the manufacture of farm machinery, household appliances, and heavy machinery, until its wastes are developing into a problem. The use of cyanide in plating as well as such heavy metals as chromium, cadmium, copper, and others adds to the list of industrial wastes that must be controlled. These wastes, in sufficient quantities to be a hazard to the stream, usually come from spills, dumping of contaminated tanks, and similar sources, rather than from a constant discharge into the sewer. Some of the industries are becoming so large, however, that the carry-over on parts removed from the plating tanks is approaching the allowable limit. Volumes have been written on oxidation, reduction, neutralization, and disposal of these wastes as a result of continuing research. The use of chlorine for the oxidation of cyanides is recognized, but the first plant scale application is just now under construction in Iowa.

In smaller installations, the use of holding tanks to collect plating wastes (if accidental spills occur or substandard tanks must be discarded) should not be overlooked. The contents of the holding tank can then be drained off over a long period of time or oxidized or reduced and then bled at a slow rate. If large quantities of sewage are available for dilution, it may be possible to reduce the concentration through controlled discharge and dilution to below any hazardous degree of concentration.

Manufactured Gas.—Gas plant wastes from the production of manufactured gas represent a sporadic problem. Although such installations have decreased in number because of the shipping or piping of gas into the state, a sufficient number are still operating to classify the waste as a problem. Such installations are usually located in large centers of population, and with careful primary treatment units can reduce the phenolic and mulch content to such a level and quantity that it can be mixed with domestic sewage without injurious effects on the treatment processes. Good reclamation procedures and reuse of water within the plant can reduce the quantity of waste and its constituents materially. Amply designed separators with scum and sludge removal facilities can be used for removal of the mulch that either floats or settles with a reduction in temperature. This material can then be salvaged for use in by-products. Further treatment of the clarifier separator effluent (by replaceable coke or similar filters) may be required. Within the writer's experience, these principles, properly applied and controlled, have permitted treatment of gas plant wastes with large volumes of municipal sewage.

Oily Wastes.—Oil wastes are a problem in some streams and sewers because of the servicing of railroad motive power and the use of cutting oils and coolants in the manufacture of farm machinery and heavy equipment. Oils and greases of the usual type can be removed by the use of gravity separators or clarifiers. The use of emulsions, however, further complicates the problem. Most large users of cutting oils or solvents process the oils for reuse; but the residue and volume rejected must be treated prior to discharge into the streams. The emulsions can usually be broken by depressing the potential of hyrogen (pH) by the use of alum or acids and, after skimming and settling, the pH-value can be raised with lime and further removal effected by settling.

Sugar Processing.—An experience with ion exchange for the purification of sugar products should be mentioned as a matter of interest, to show how complications can occur in the disposal or treatment of wastes. The waste from this industry was lagooned for disposal and this operation was reasonably satisfactory until the regeneration waste of the ion exchangers was added. The exchangers were regenerated by sulfuric acid. After a reasonable period of time, to allow good digestion to become established, the resulting odor of hydrogen sulfide could be detected for considerable distances. A change to hydrochloric acid in the regeneration process eliminated the odor problem.

Miscellaneous Waste Problems.—The wastes from the manufacture of starch and its allied products, alcohol, furfural, paper, and beverages (including beer) are all found within the boundaries of the State of Iowa. Some of these industries are beyond the control of the stream pollution law and for others treatment is provided.

The wastes produced in some of the new types of industries include flouro-silicate wastes from the manufacture of phosphate fertilizers, arsenic, and other compounds from the production of biologicals and the wastes from the manufacture of insecticides. These wastes contain complicated organic compounds, treatment of which requires research, time, and effort.

The effect of such wastes can be realized, however, when it is considered that two of the worst fish kills in recent years have occurred as a result of the discharge of an insecticide into a sewer system equipped with treatment, and of a change in the type of raw waste discharged into a stream because of a toxic preservative used to prevent mold formation in food containers. These intermittent occurrences can be more damaging to fish and other aquatic life than the continuous discharge of improperly treated sewage or wastes. The suddenness of their effect prohibits migration of the biological life, and traps them below the outlets into the streams.

Conclusion

The three points presented at the beginning of this paper have been established. An industrial waste problem does exist in Iowa although known processes and methods of treatment have controlled a large proportion of it. There is much work to be done from the standpoint of the installation of new facilities and the expansion or replacement of those in existance. This will require not only the united effort of all official agencies but the wholehearted cooperation of all industries. It should be remembered that, although anyone engaged in the profession of sanitary or public health engineering (whether publicly or privately employed) stands ready, willing, and eager to be of assistance, it is still largely industry's own problem to analyze wastes and develop methods of treatment.

Acknowledgment

At the annual meeting of the Iowa Engineering Society at Des Moines on January 23, 1951, a paper entitled "Status of Industrial Treatment in Iowa" was presented by the writer.[7] The present paper has some modifications

[7] "Status of Industrial Waste Treatment in Iowa," by Paul Bolton, *The Exponent*, Iowa Eng. Soc., April, 1951, et seq.

of the former work, adapted to the requirements of the Society for purposes of encouraging widespread discussion on a general plane.

The task of studying the official reports from the several agencies of the various levels of government was notably lessened by the assistance of the persons charged with the promulgation of the reports. This cooperation was the only means of establishing the factual information necessary for a basis of the paper. This assistance was sincerely appreciated.

Deep gratitude for the information taken from both published and unpublished reports as referenced and those studied but not drawn upon is also expressed.

Also acknowledged is the assistance of several of the engineers of the Iowa State Department of Health who helped assemble the information into summary form for the final presentation.

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